# Mars Sample Return


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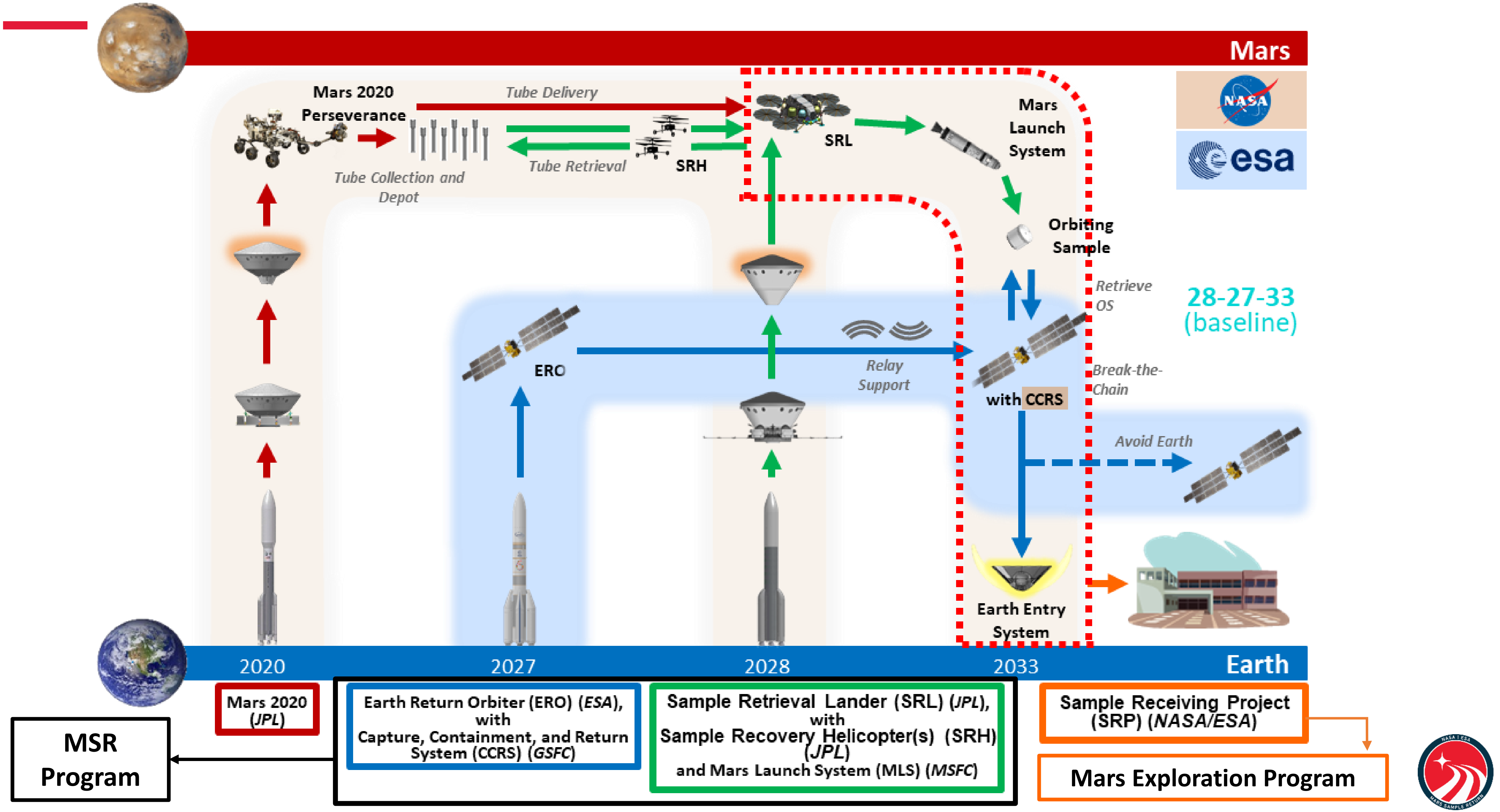
# Planned MSR Campaign architecture overview



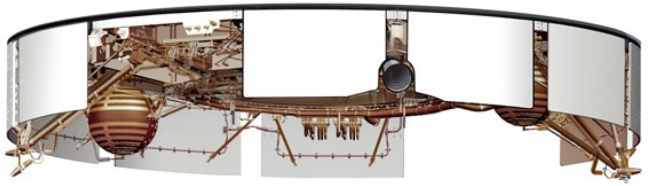
# MSR in action: a preview

# Why Mars Sample Return?

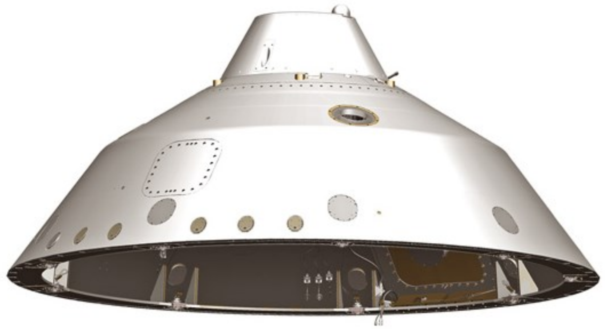
- Seek **signs of ancient life** on the Red Planet by collecting compelling samples of **rock**, **regolith** (broken rock and dust) and **atmosphere** for a possible return to Earth.
- Years of data from past missions to Mars have confirmed that some areas offered **habitable conditions** that were capable of supporting life in the past.
  - Much of this warmer, wetter period is believed to have occurred about three billion years ago, in the same geologic timeframe as early life was blooming on Earth.
  - This commonality raises the prospect that discoveries on Mars can give important insights about the origin and evolution of **life on Earth**.
- MSR would fulfill many years of external guidance to NASA, including the top recommendation of the U.S. planetary community in their most recent national strategy, titled “Vision and Voyages for Planetary Science in the Decade 2013-2022”.
- Beyond the search for life, the MSR campaign could also help scientists understand:
  - the detailed **geological history** of Mars,
  - the evolution of its **climate**,
  - any **hazards** in the dust of the Red Planet that could affect future **human** explorers.

# Mars 2020 – The mission

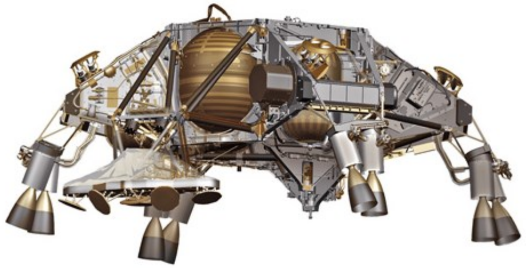
# Mars 2020 – The spacecraft



- **Cruise stage**
  - Supports the entire vehicle during the cruise to Mars, keeps it powered up, in communication, and on target. It features a large solar array, radio antennas, fuel tanks and small thrusters.



- **Backshell**
  - Part of the aeroshell, it protects the rover during its turbulent descent to Mars. It houses thrusters that fire during the guided entry portion of entry, descent and landing. At the top is the canister from which the parachute is released during descent.



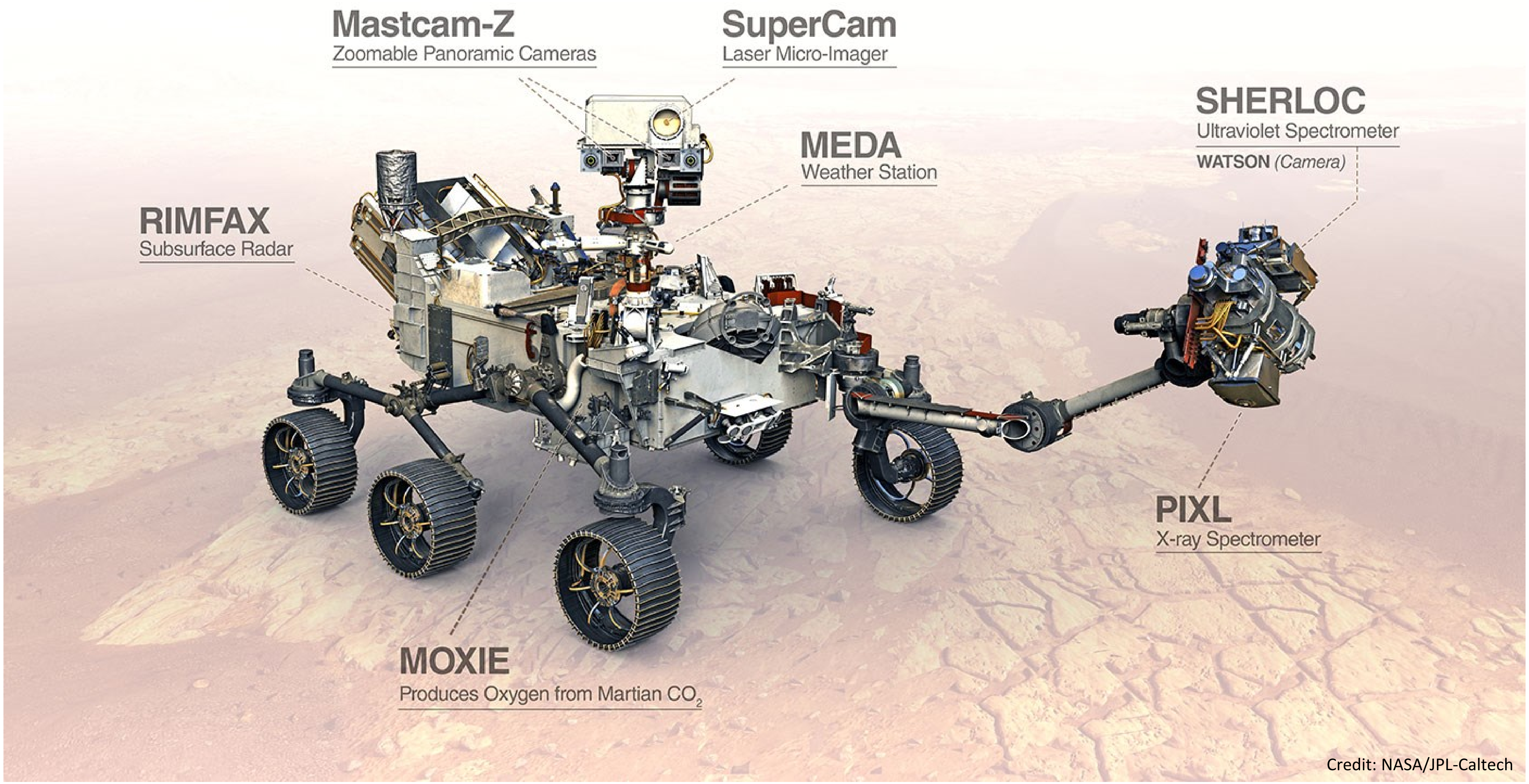
- **Descent stage**
  - Separates from the backshell and uses eight engines to slow the final descent. It contains the landing radar system used to make last-minute decisions about touchdown. Just before touchdown, the descent stage lowers the rover on cables before gently placing it on the surface. Once the rover is on the ground, the descent stage flies off to make its own uncontrolled landing on the surface, a safe distance away from the rover.

- **Rover**
  - A six-wheeled vehicle carrying cameras and science instruments. Designed to explore the Martian surface, make discoveries and collect samples.

- **Heat Shield**
  - Helps slow the vehicle down during its final approach, while protecting the rover inside from the intense heat experienced during entry into the Martian atmosphere. It could be exposed to temperatures as hot as ~1300ºC as it descends.

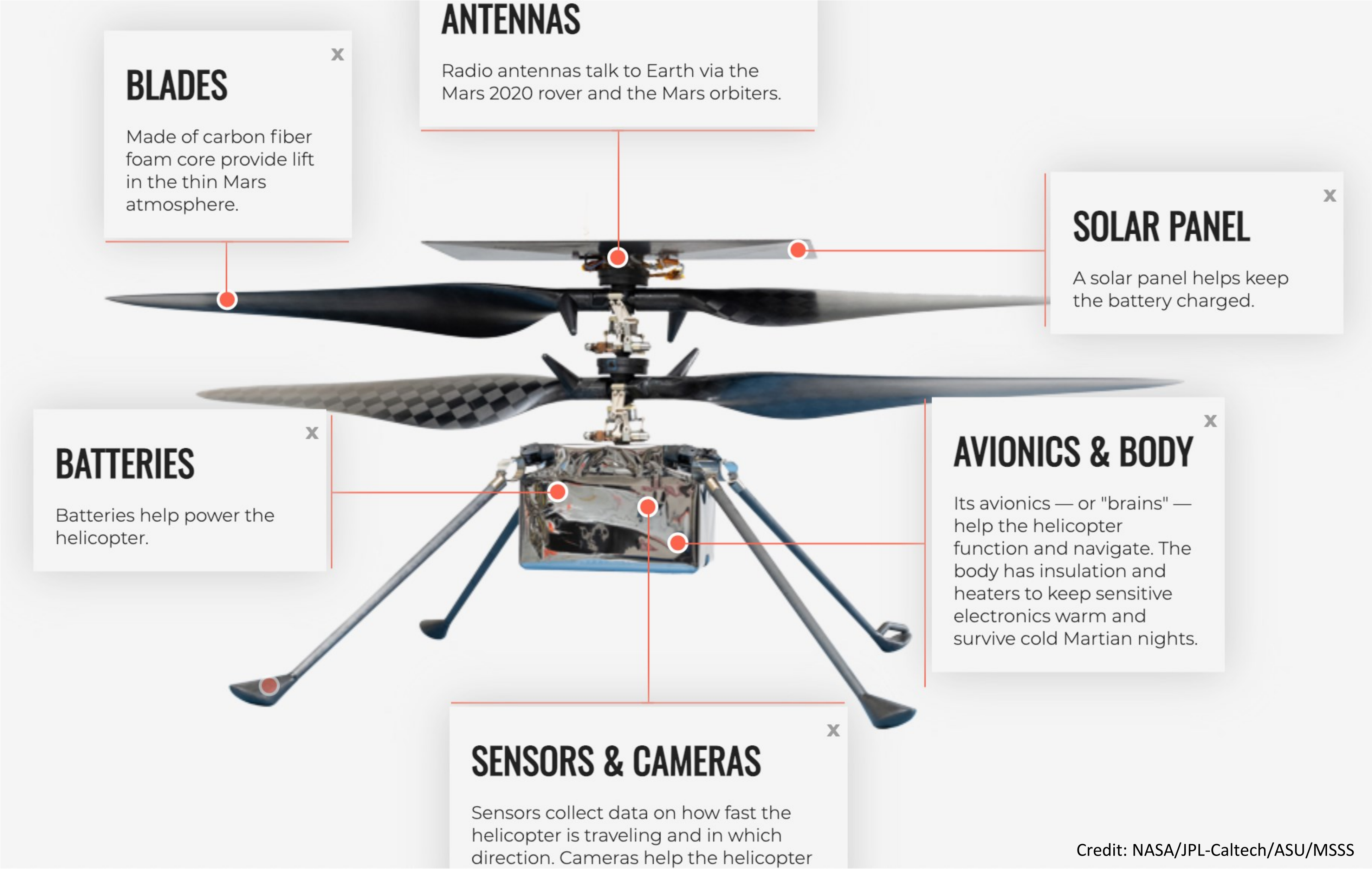
Credit: NASA/JPL-Caltech

# Mars 2020 – The instruments




Credit: NASA/JPL-Caltech

# Mars 2020 – Ingenuity



# Mars 2020 – Ingenuity


| Property | Value |
|---|---|
| Mass | 1.8 kg |
| Power | 350 W/flight delivered by solar panels that recharge Li ion batteries |
| Rotor length | 1.2 m |
| Flight range | < 300 m |
| Flight altitude | < 5 m |
| Flight duration | < 90 s |

- **First** test of **powered flight on another planet**.
- Built to be **light** and **strong** enough to stow away under the rover while on the way to Mars, and survive the harsh Martian environment.
- Powerful enough to **lift off in the thin Mars atmosphere**, which is less than 1% the density of Earth's.
- Designed to fly for up to 90 seconds to distances of almost 300 meters at a time and about 3-5meters from the ground. This is no small feat compared to the first 12-second flight of the Wright Brothers' airplane.
- The helicopter flies on its own, **without human control**. It must take off, fly, and land, with minimal commands from Earth sent in advance.

# Mars 2020 – Where are Perseverance and Ingenuity now?

mars.nasa.gov/mars2020/mission/where-is-the-rover/

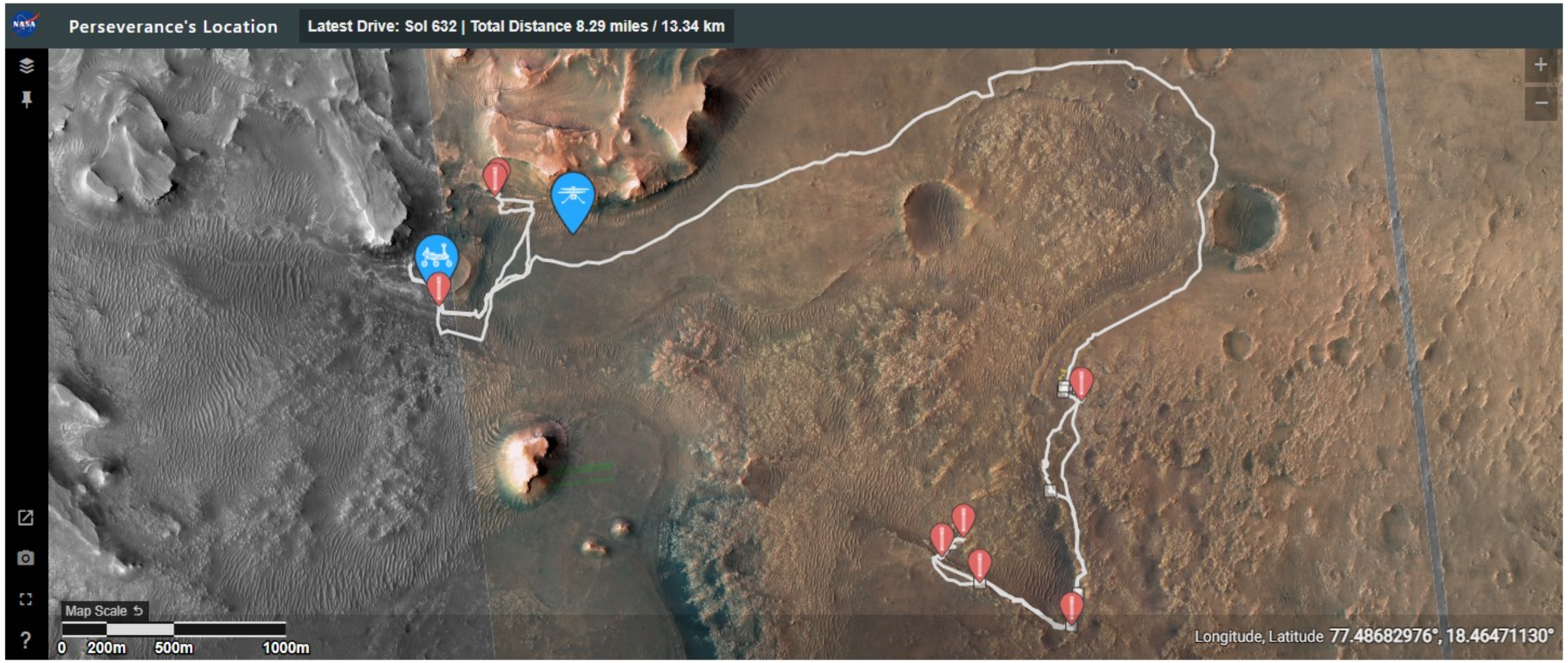
NASA Science
MARS 2020 MISSION PERSEVERANCE ROVER

Mission Timeline Spacecraft News Multimedia Participate All Mars

Mission › Where is Perseverance?

## Where is Perseverance?

DAYS ON MARS 640 : 19 : 31 : 44
SOL HRS MINS SECS

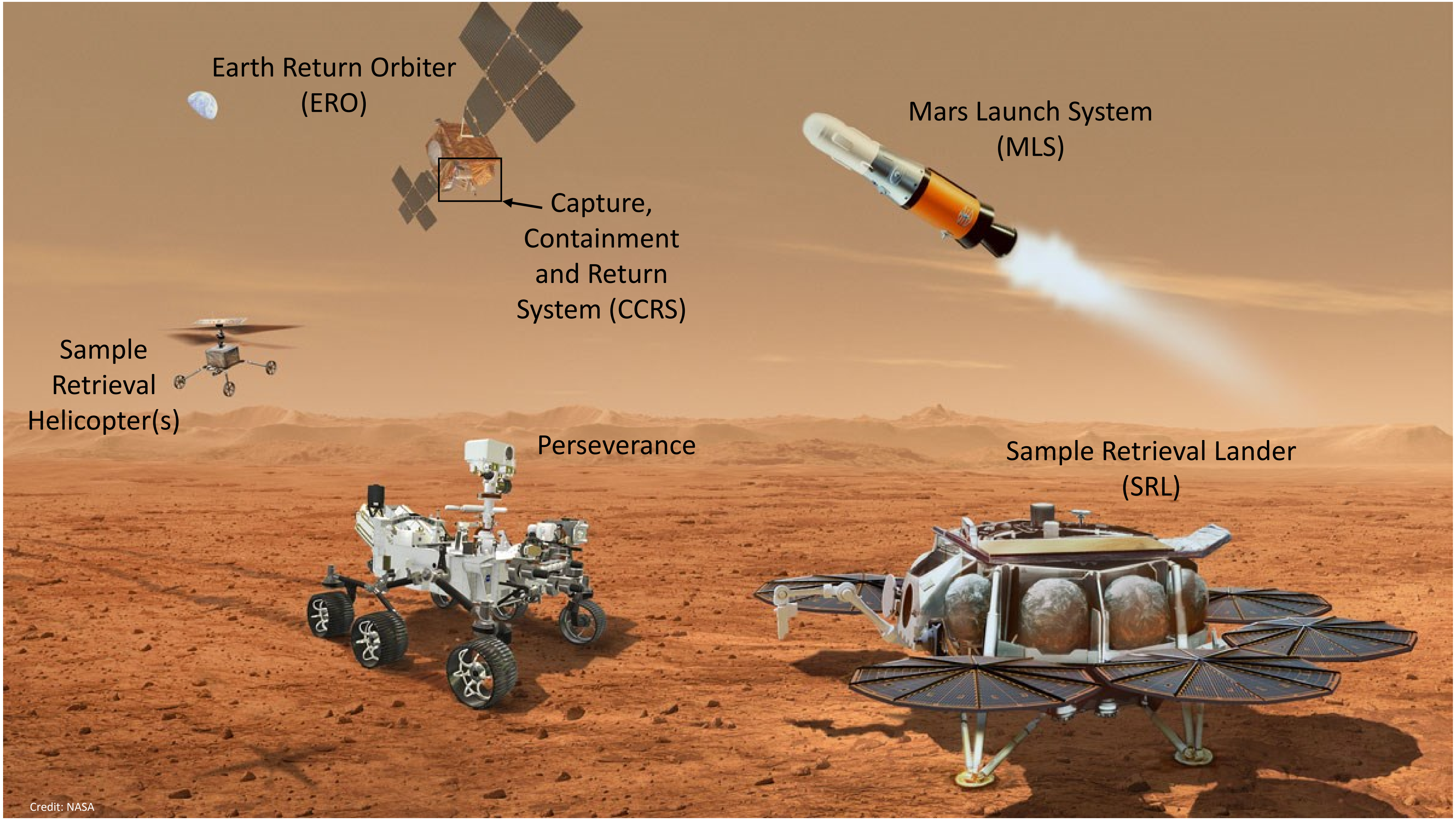



10.4K SHARES

**Perseverance Rover Location:** This interactive map shows the landing site for NASA's Perseverance rover within Jezero Crater. Perseverance landed on Feb. 18, 2021. The map also shows the location of the Mars Helicopter.

View full experience | Using the map tools | Embed map

# What's next?

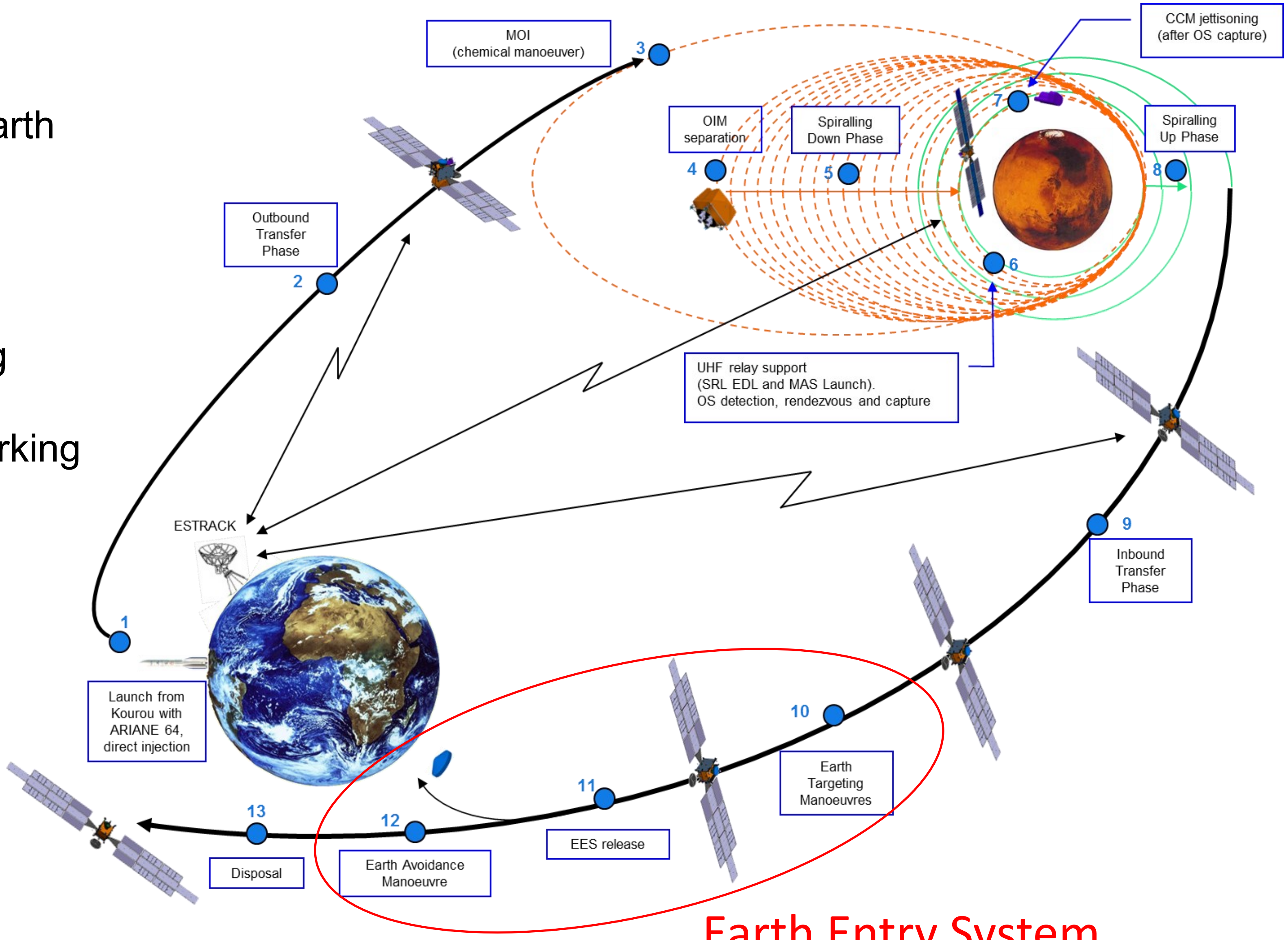


Earth Return Orbiter
(ERO)
Capture,
Containment
and Return
System (CCRS)
Mars Launch System
(MLS)
Sample
Retrieval
Helicopter(s)
Perseverance
Sample Retrieval Lander
(SRL)
Credit: NASA

# ERO-CCRS mission overview

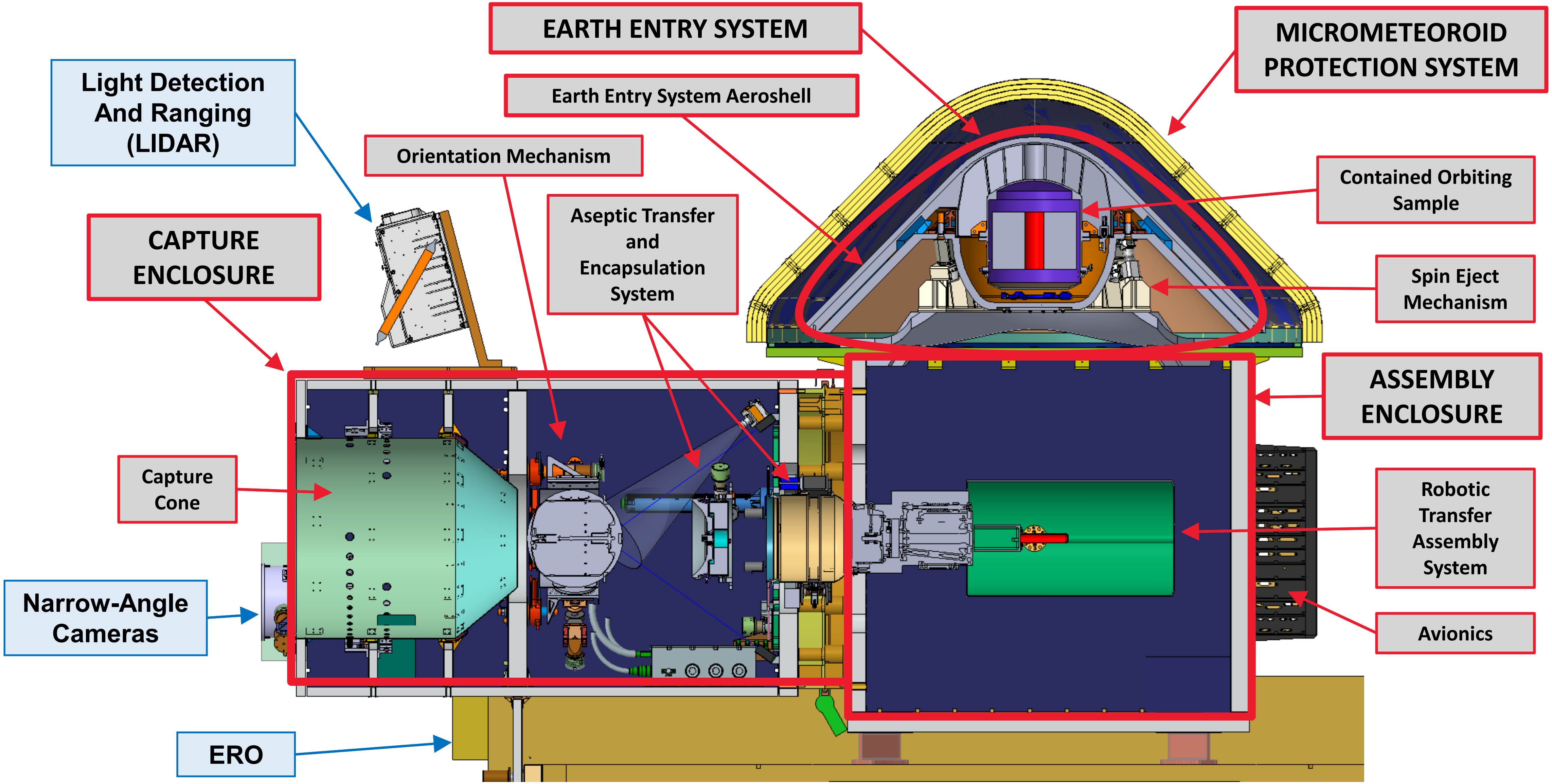
- Mission objectives:
  - Capture the OS and bring it back to Earth
  - Relay support for Mars assets

- Nominal mission (“28/27/33”):
  - Launch and near-Earth commissioning [30 days]
  - Outbound transfer with heliocentric parking orbit [3 years]
  - Mars orbit insertion [2 weeks]
  - Spiral down [<1 year]
  - Low Mars orbit (relay support, OS rendezvous, OS containment) [1-1.5 years]
  - Spiral up [<1 year]
  - Inbound transfer [1 year]
  - EES delivery phase [few days]
  - Retirement [few days]




Earth Entry System Delivery Phase

# CCRS payload overview



# What is planetary protection?

**FORWARD PLANETARY PROTECTION (FPP)**

From NASA Procedural Requirement NPR 8715.24:

“Planetary protection is the practice of **protecting solar system bodies** from harmful contamination by terrestrial materials to enable scientific exploration and **protecting the Earth-Moon system** from possible harmful extraterrestrial contamination that may be returned from other solar system bodies.”

**BACKWARD PLANETARY PROTECTION (BPP)**

Also see:

1. *Article IX, UN Space Treaty* (UNOOSA 2017, Report of the Committee on the Peaceful Use of Outer Space, 60th Session, A/72/20, United Nations, New York)
2. *Planetary Protection Policy*, Committee on Space Research (COSPAR), 2021

# How to implement Backward Planetary Protection?

## BREAK THE CHAIN OF CONTACT BETWEEN MARS & EARTH

**Active, surface-to-surface (Mars-to-Earth)** process to satisfy BPP goals by prohibiting uncontrolled transmission and release of **extraterrestrial material of concern** into Earth's biosphere.

### PARTICLE CONTROL (“Leave behind”)

Adhesion
Transmission
Emission

### STERILIZATION (“Kill”)

Inactivation
(natural or engineered)

### CONTAINMENT (“Lock up”)

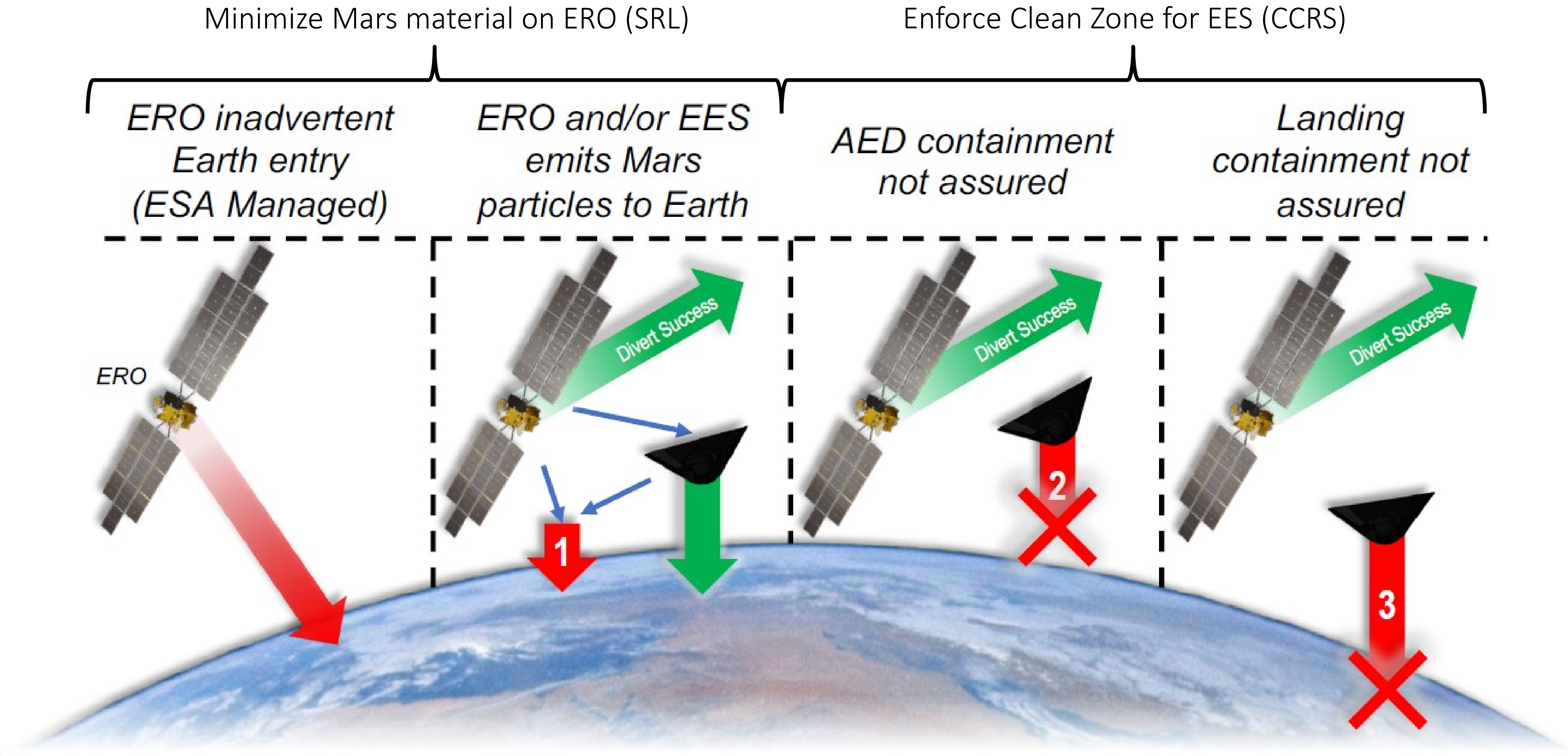
Sealing
Encapsulation
Isolation
Blocking

### ASEPTIC TRANSFER

Move something from a dirty volume to a clean volume without transmitting Mars material

# Particle Control

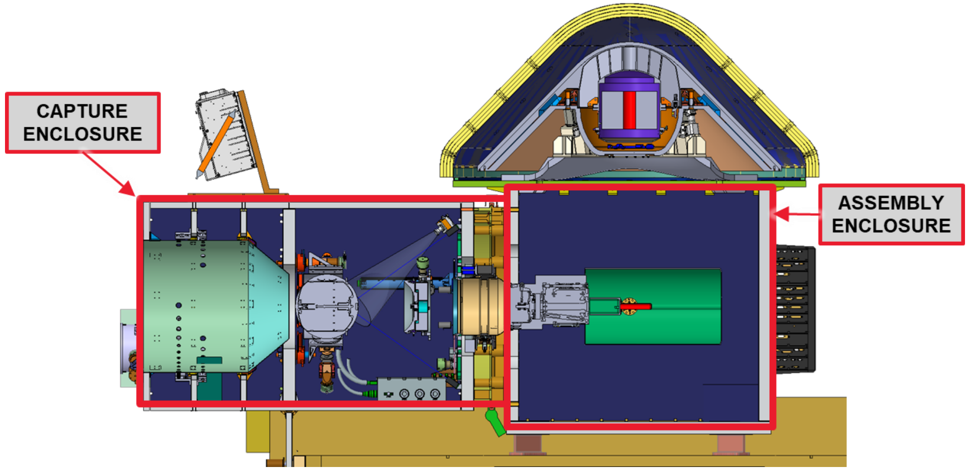
- There are 5 primary paths of Mars material that can enter Earth's biosphere
- End-to-end, physics-based, analytical framework developed to track particles on hardware

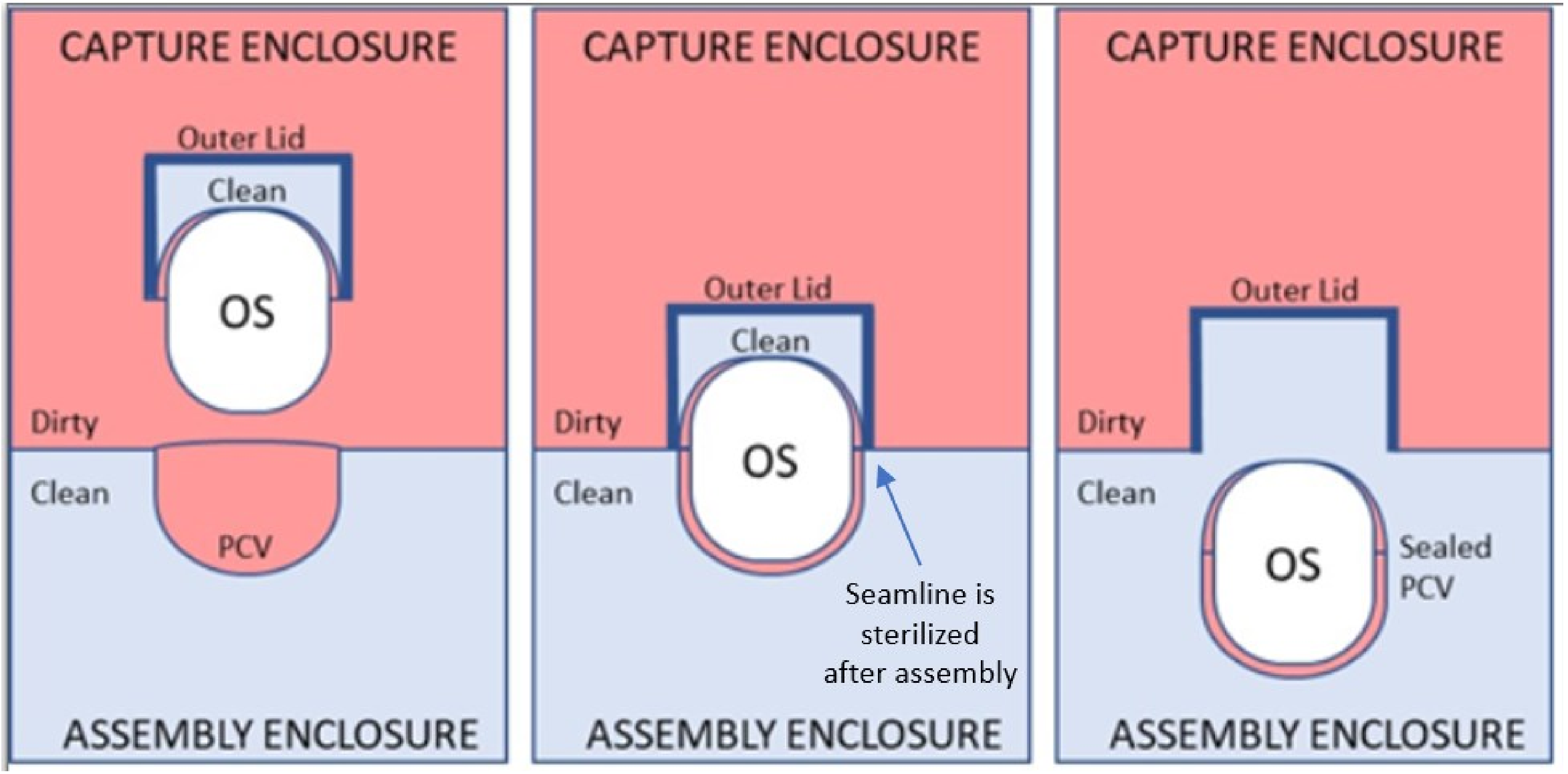


# Aseptic transfer and jettison

**Potential biohazards from Mars**

- **Bacterial endospores** as the bounding case for heat-resistance in whole organisms
- **Yeast prions** as the bounding case for resilient proteins that can proliferate catalytically

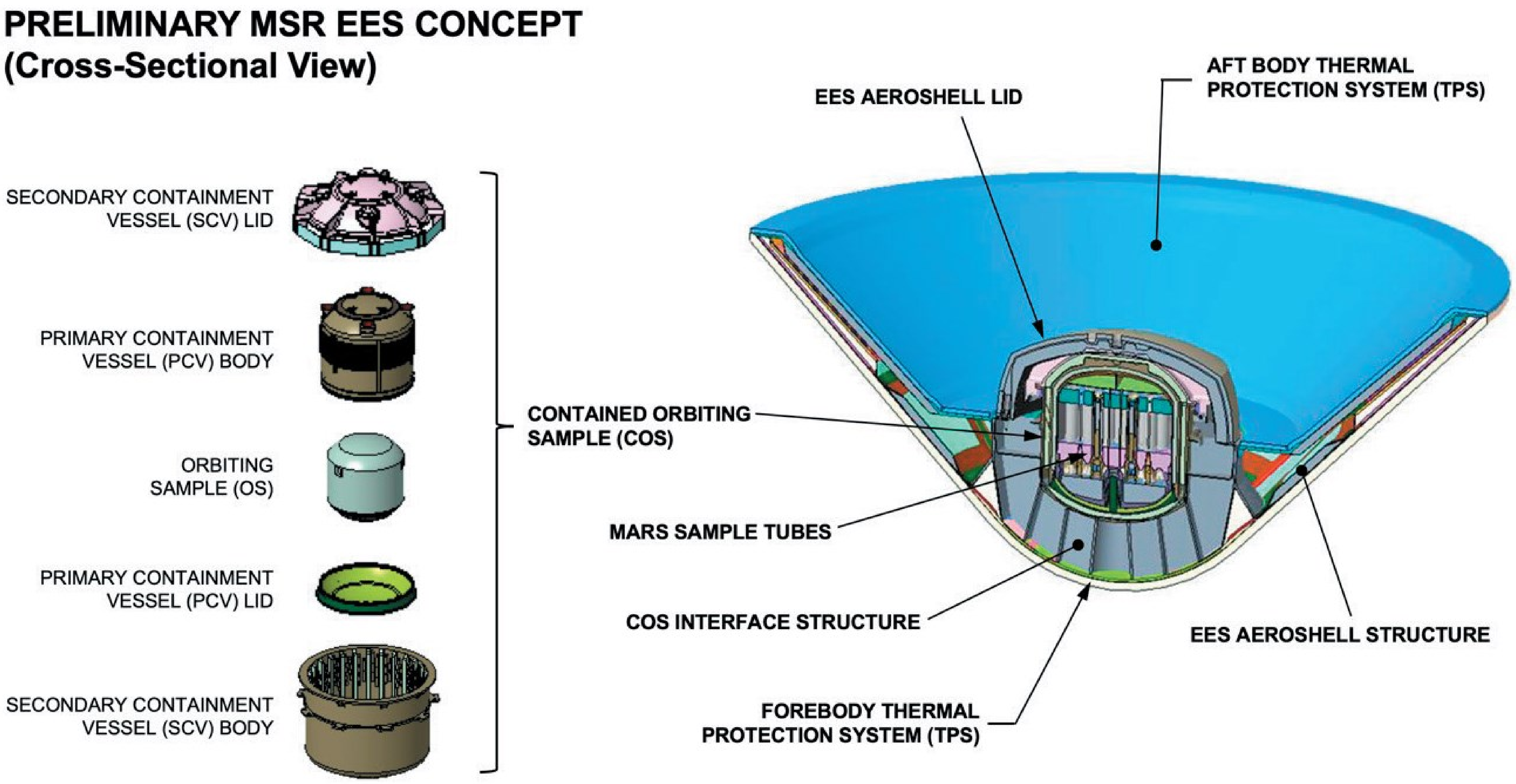


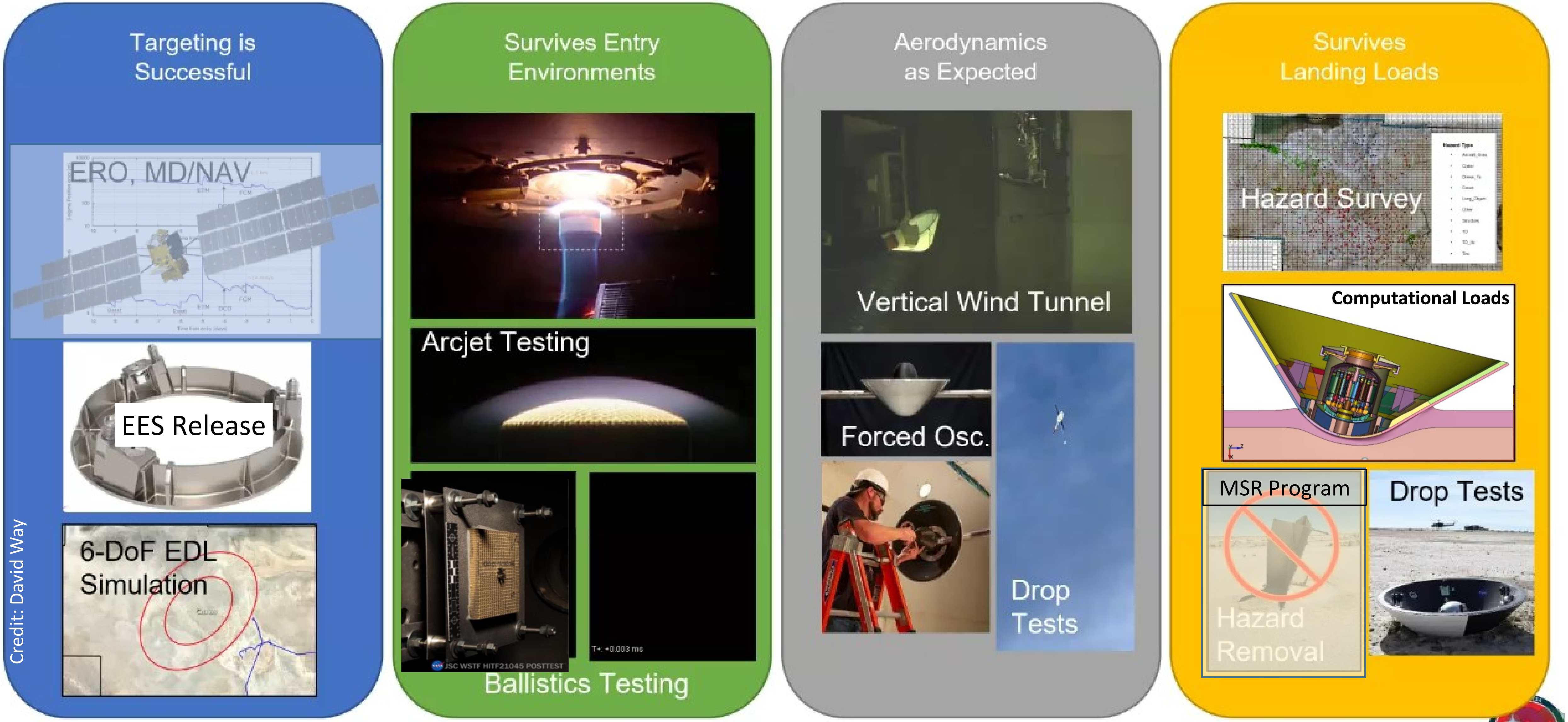

Cataldo et al., 2022, *"Mars Sample Return – An Overview of the Capture, Containment and Return System"*, 73rd International Astronautical Congress (AC), Paris, France

- After the Primary Containment Vessel (PCV) is formed, its seal would be heated to > 500°C, so that any material on exposed portions of the PCV base or lid is **sterilized**.
- The Capture Enclosure would be **jettisoned** after the Contained Orbiting Sample is installed into the EES.

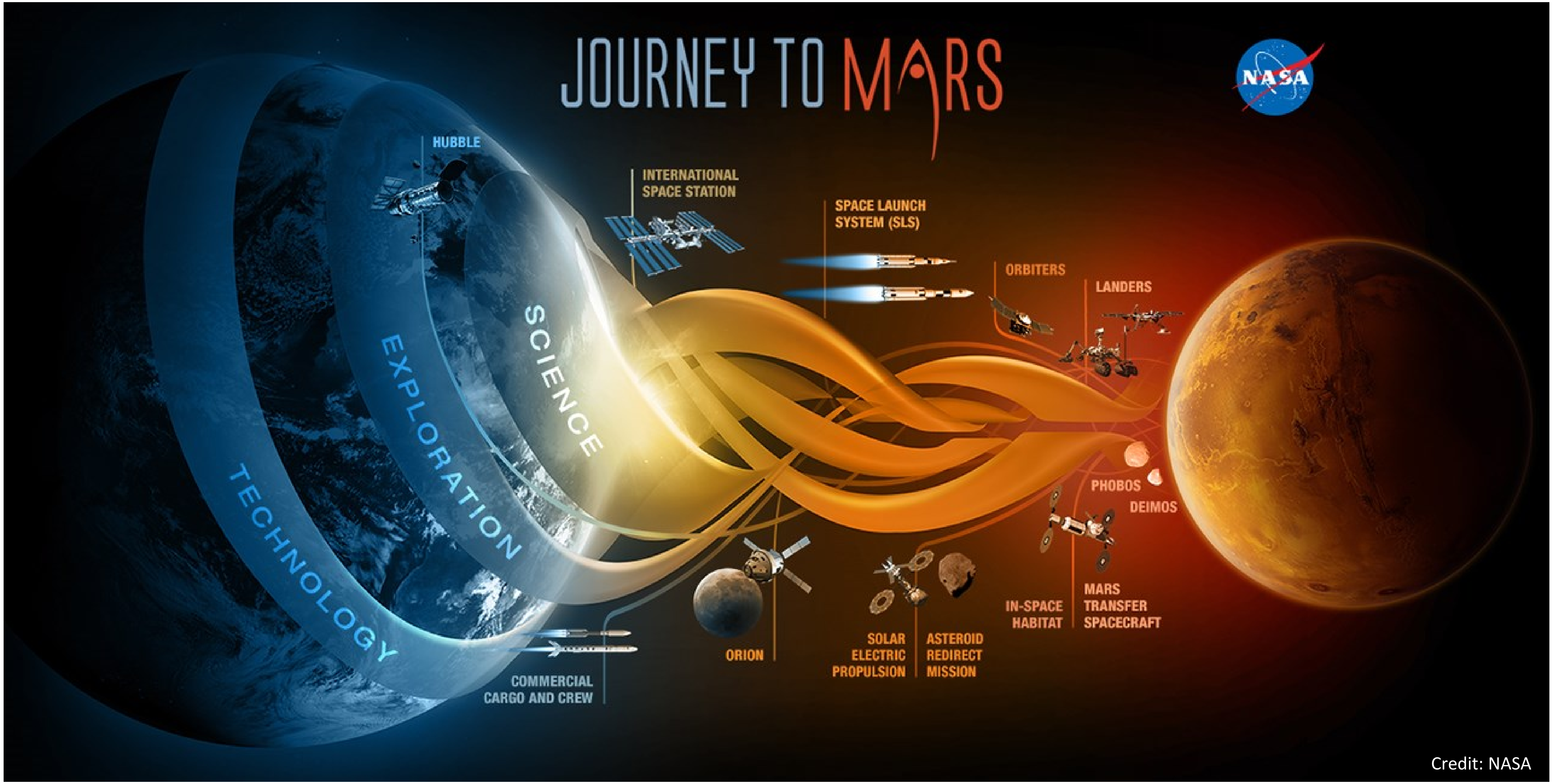
# Containment Assurance



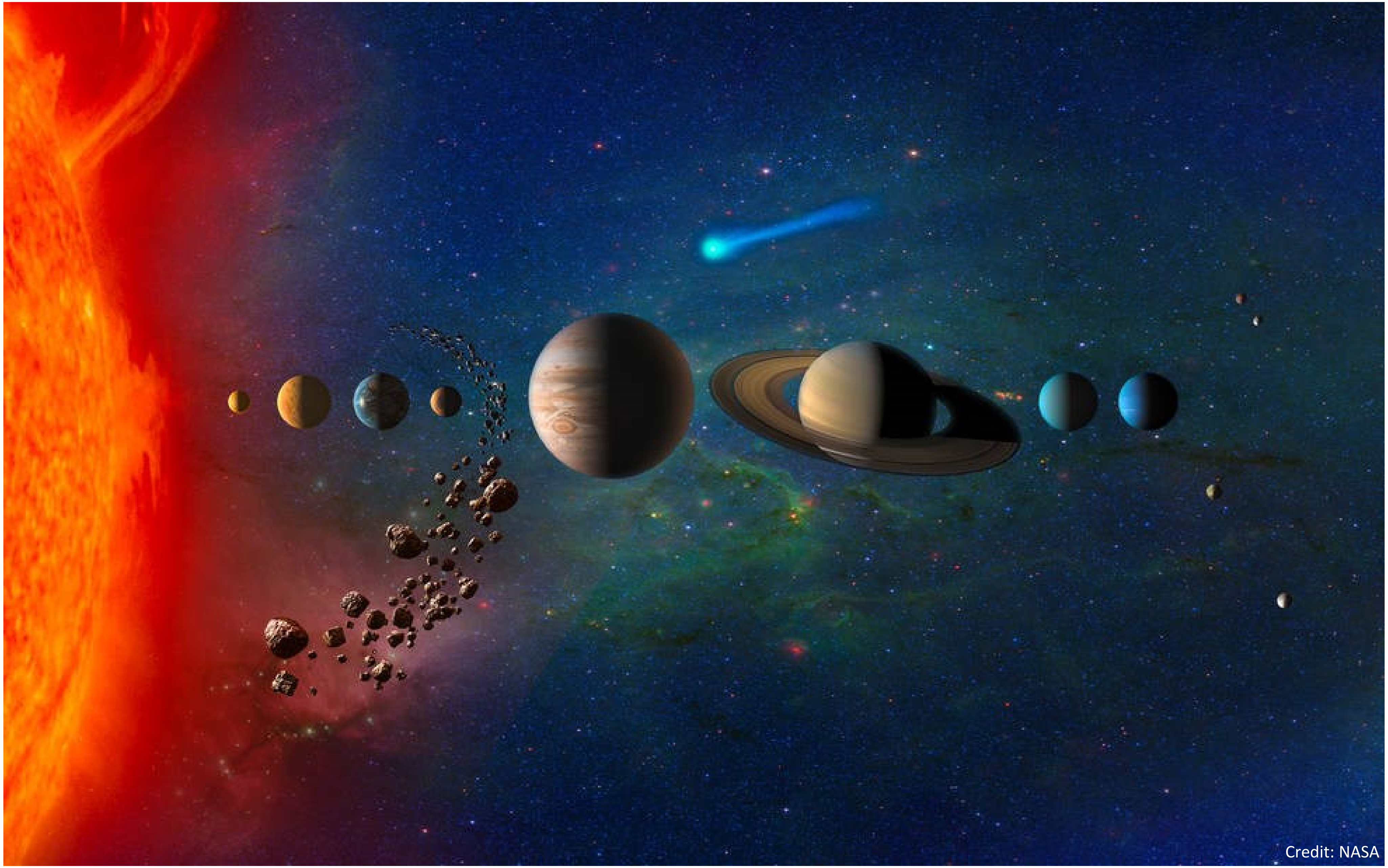
# Containment Assurance



# Follow Perseverance's adventures on social media @NASAPersevere and @NASAMars



# Exploration never ends! Will you be the next explorers?



# Many thanks to:

EUROAVIA PISA

For any information, follow me at:

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